SCAR Group of Specialists: Subglacial Lakes

Abstract for meeting of September 17, 18, 2001, Bologna, Italy

JPL DEEP SUBGLACIAL IN-SITU TECHNOLOGY AND SCIENCE PROGRAMS

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The great ice masses of Earth, Mars, and Europa are sites of significant scientific interest for climate history, climate processes, and life. As a consequence, NASA technology programs have undertaken to determine the objectives, assess the requirements and address technology development for exploration and scientific observations in these sites. We will discuss some simple first steps in the area of access to the deep subglacial through the development of the JPL Active Cryobot, a modified Philberth thermal probe. We will also address a parallel scientific program focused on exercising this technology in understanding the fundamental properties of the deep subglacial, e.g., the mineralogic, gas and brine inclusions, fabric, temperature, bioload, etc.

JPL DEEP SUBGLACIAL IN-SITU SCIENCE AND TECHNOLOGY PROGRAMS

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Earth and Planetary Deep Subglacial Science

Earth:

Ice Dynamics: Basal Processes, Changes in Frozen-Wet Boundary

Paleoclimatology (Glaciochemistry): Composition

Subglacial Lakes: Water Chemistry, Dynamics

Mars:

Climate History: Chemical Horizons, Dust Mineralogy

Biology: Organics, Chemical Strata, Sediment Mineralogy

Europa:

Biology: Biochemical Composition, Organic Abundance, Particulate Makeup, Chemical Strata, Ice Biota

Planetary History: Profiles of Inorganics, Sediment Character

TECHNOLOGIES FOR PLANETARY SUBGLACIAL SCIENCE

- **Scientific In-Situ Sample Acquisition Process**
  - Where on planet/Where at site/What sample/What in sample?
- **Access to Subsurface**
  - Mobility to multi-kilometer depths
- **"Documentation" In the Subglacial**
  - Regional Scale: radar or sonar mapping
  - Local Scale: Photography, sonar, radar
  - Microscale: Microscopy, Electron or Visible Light
- **Scientific Observation**
  - Micro-instrumentation: Mass-Spec, Raman/Fluor. Spec., etc
- **Planetary Protection:** An Issue of Increasing Significance
  - Cleaning, Verification

SPECIFYING THE JPL CRYOBOT DEVELOPMENT

CRYOBOT NEEDED FOR:

- **OBJECTIVES**
  - In-Situ Science in Surrounding Ice, Meltwater
  - Chemistry; Gas Analysis; Particulate Study; Inclusions
  - Biomarkers
- **REQUIREMENTS**
  - Space-Capable (Mass/Volume/Power/Data)
  - Range to 30 km
  - Non-Contaminating
  - Tolerate Environmental Uncertainty
  - Accommodate Science Instrumentation

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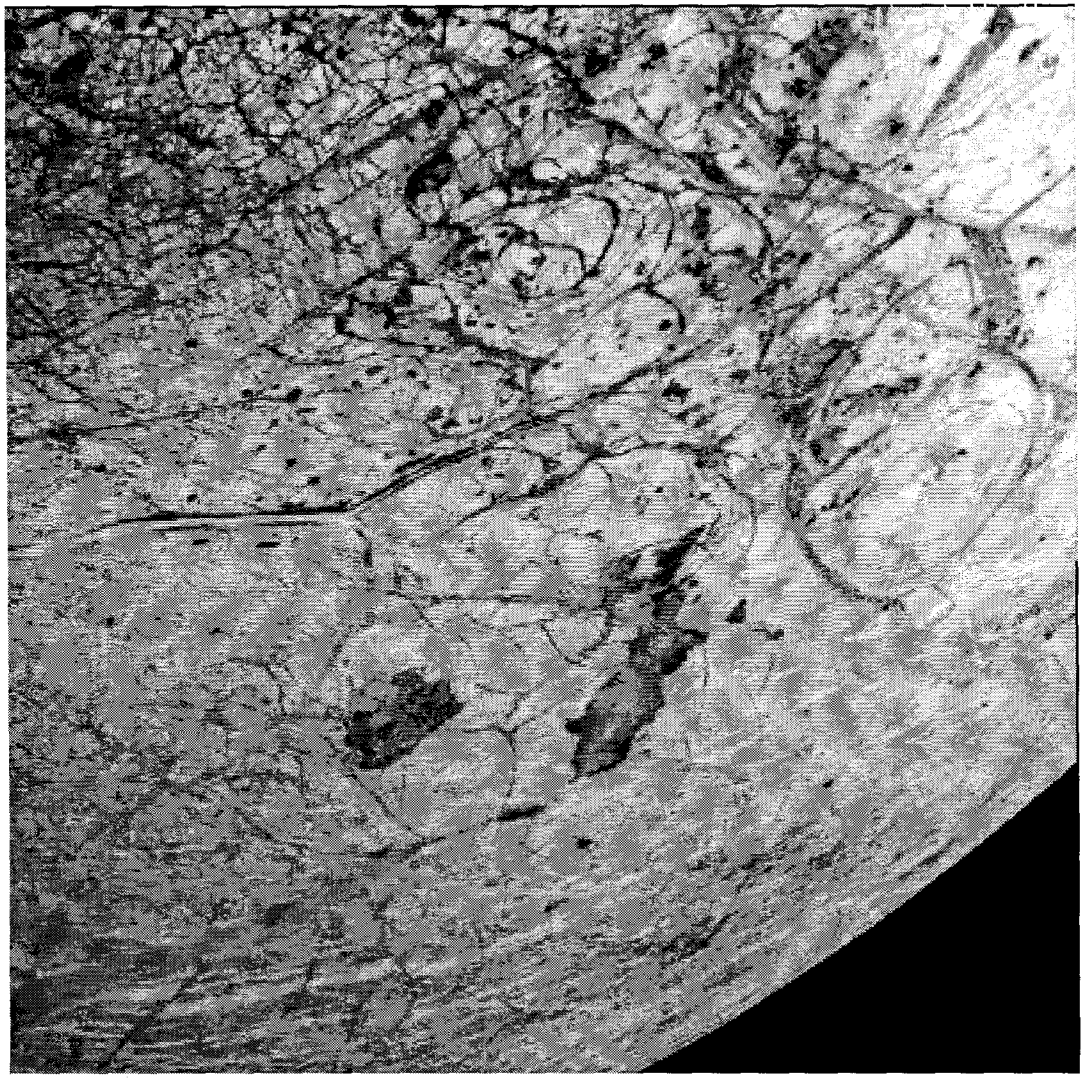
Europa



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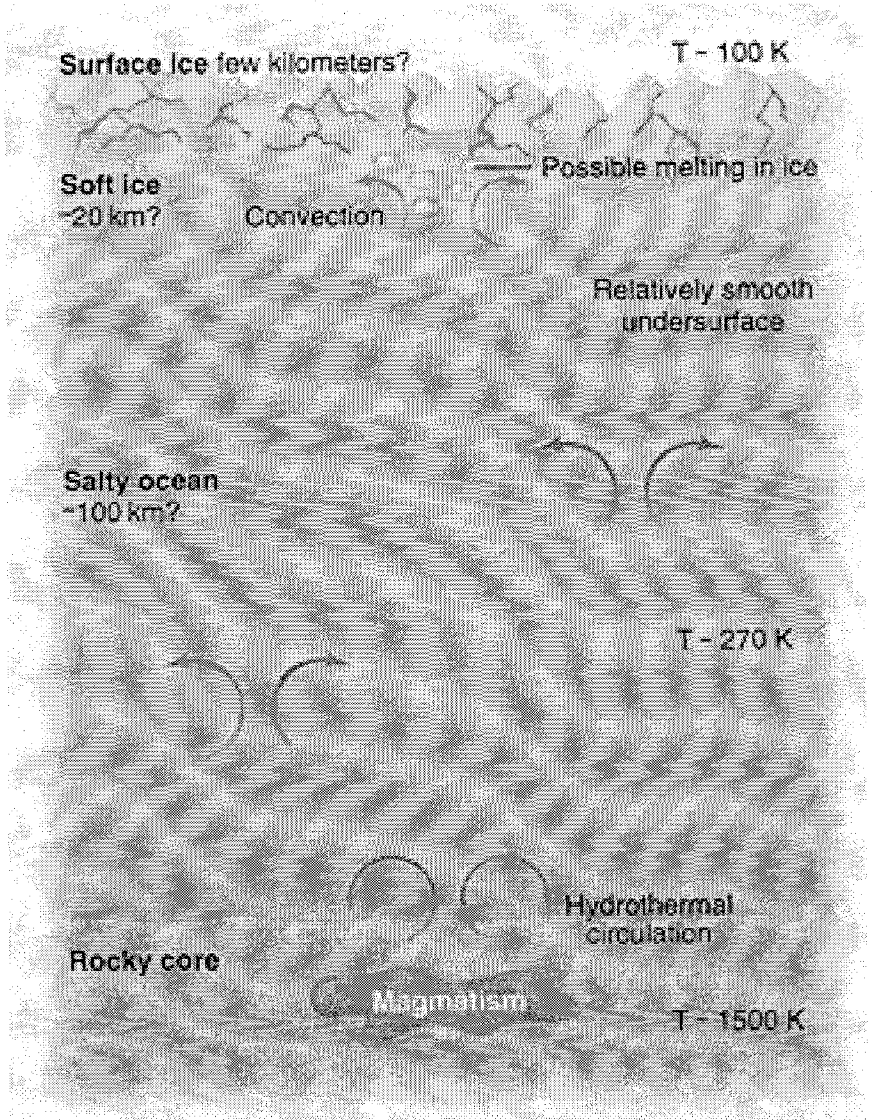

Possible processes in Europa. This is a montage; it is unlikely that all of these processes happen in the same place at the same time.

A Concept of the Europa Ice and Ocean Due to David Stevenson of Caltech, *Science*, 2000

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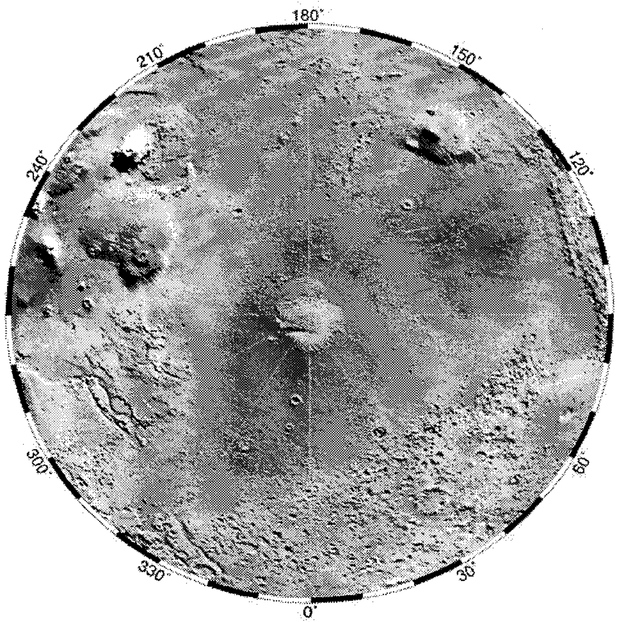
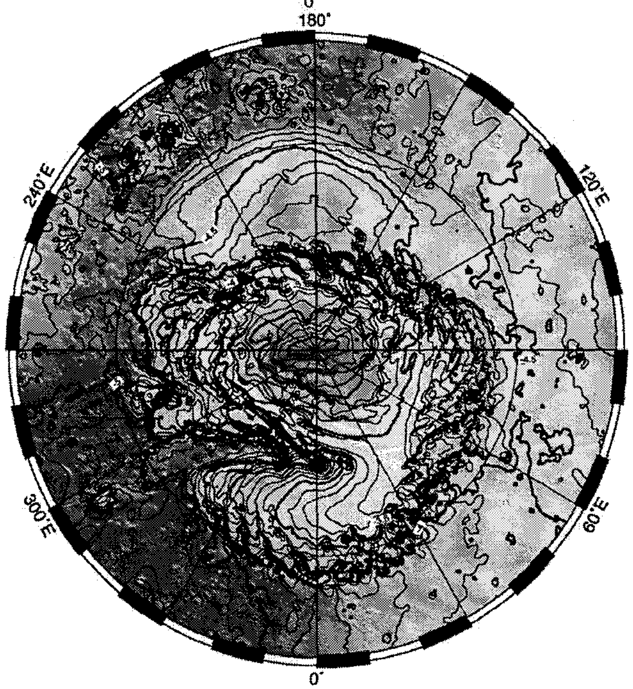
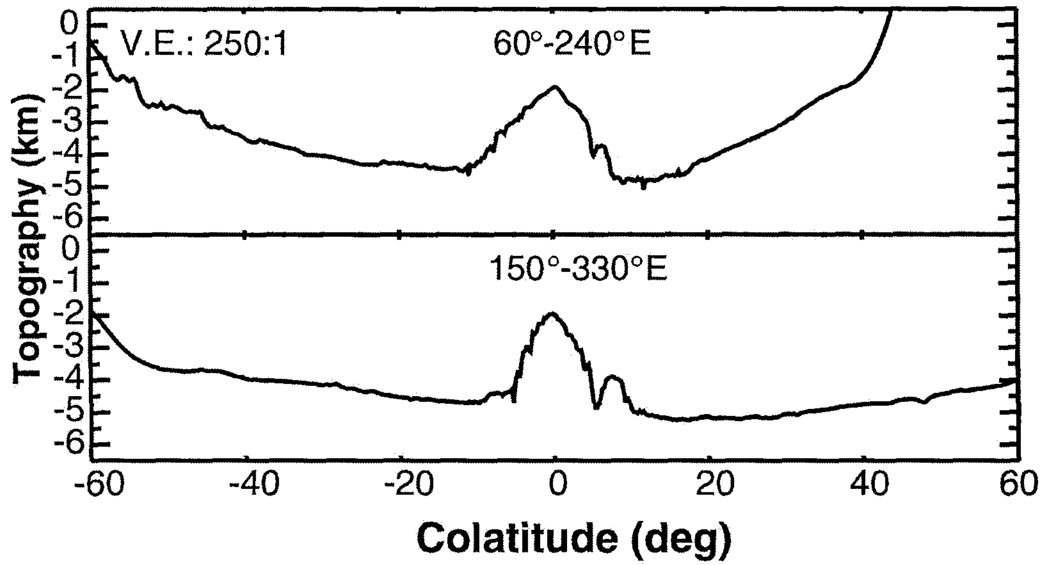
Mars North Pole







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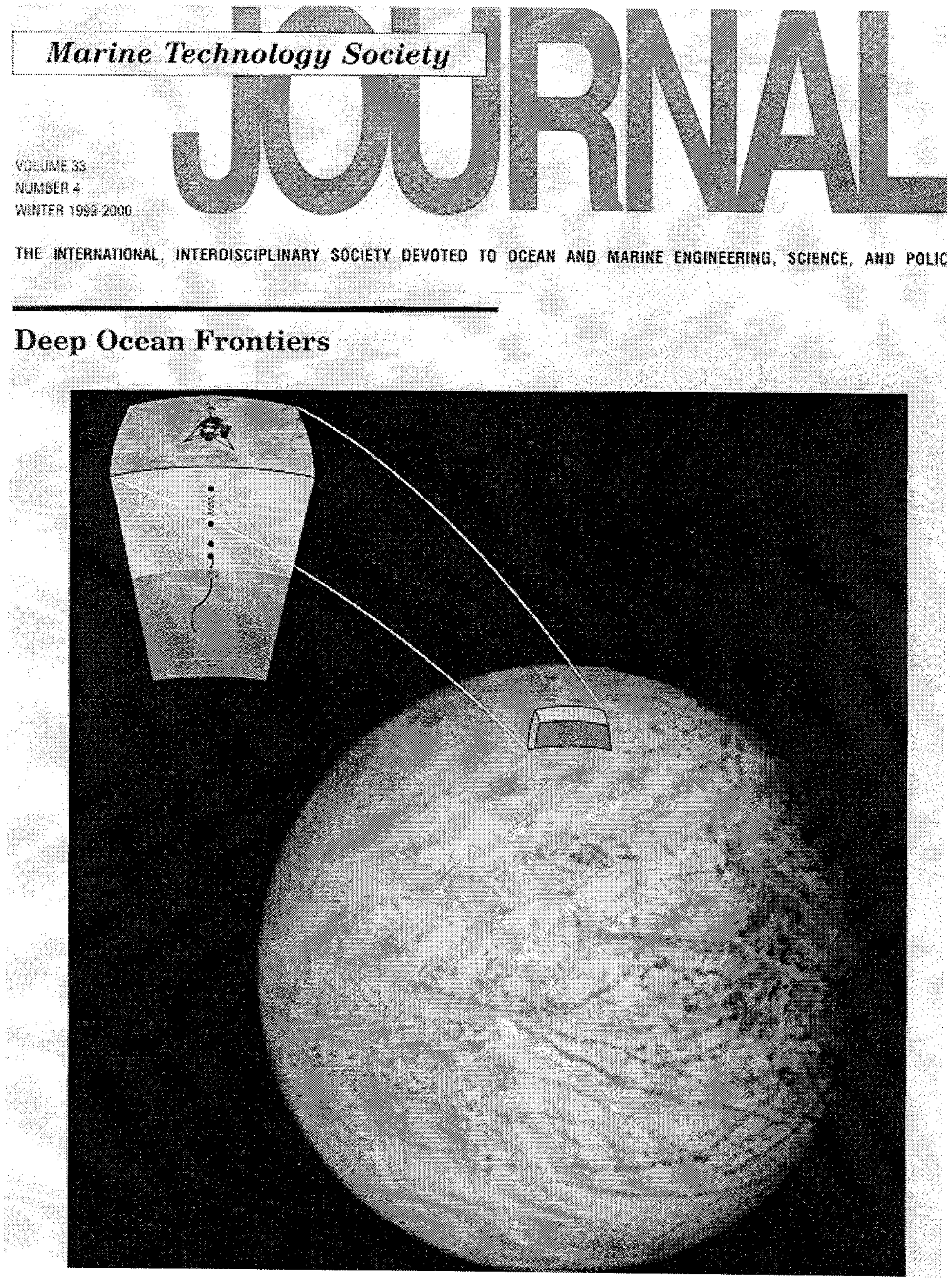
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Deep Ocean Frontiers

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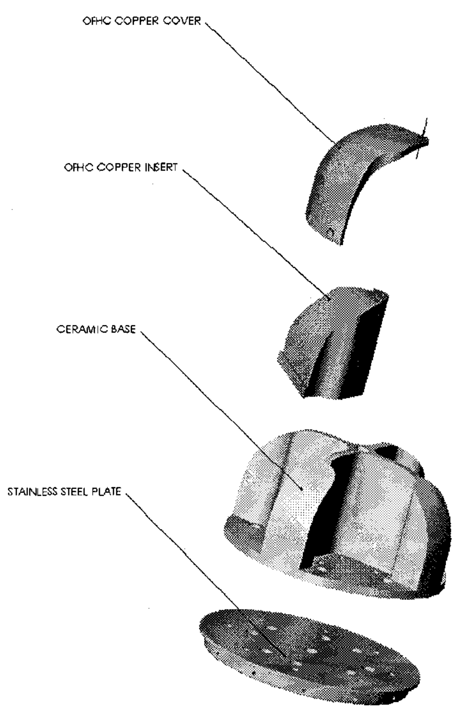
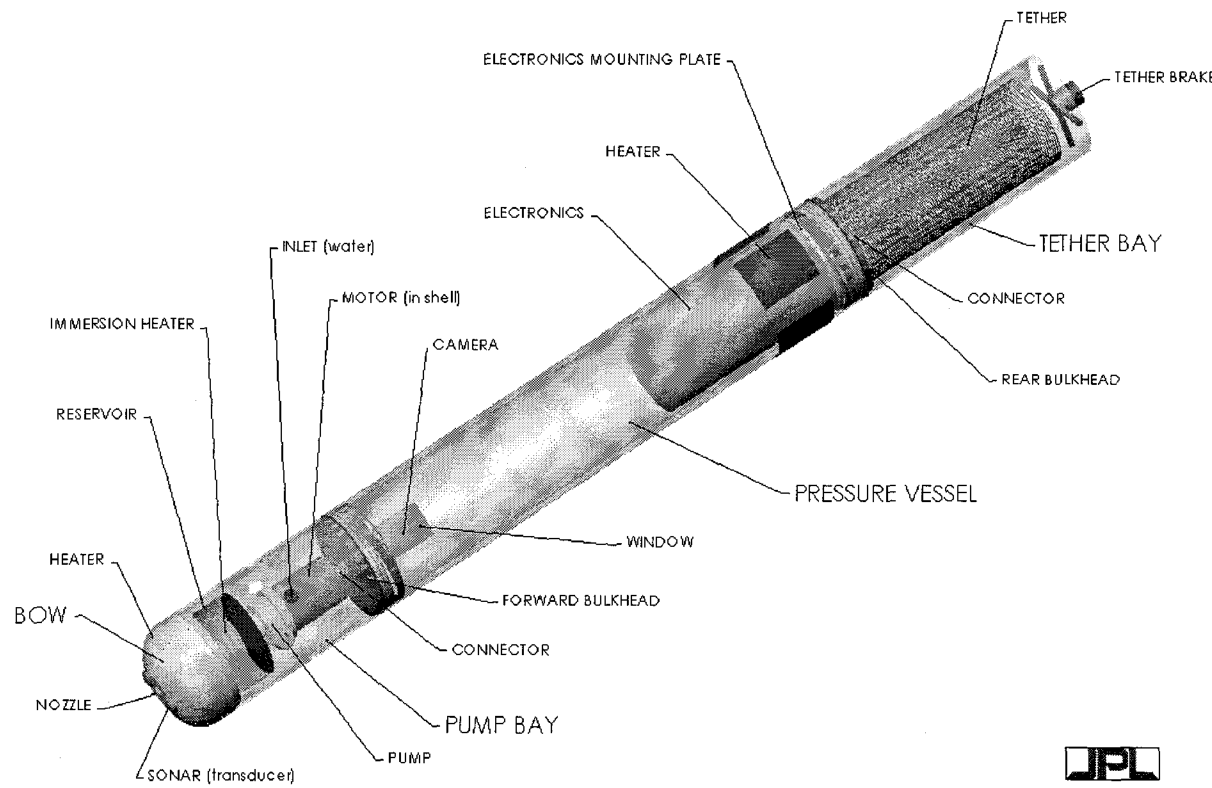
SUBGLACIAL ACCESS:
NASA-JPL "Cryobot" Design
Before NASA These Were Called Philberth Probes





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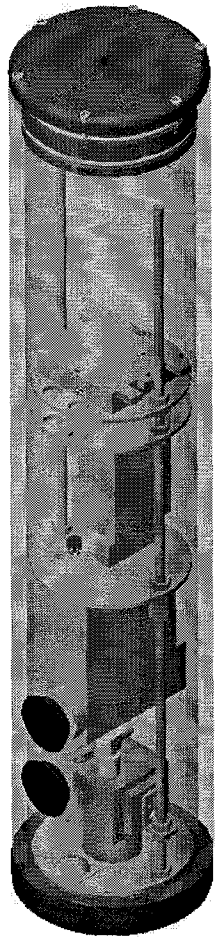
SUBGLACIAL OBSERVATIONS:
Ice Camera Probe
Caltech-JPL West Antarctic Basal Ice Study



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KEY PERFORMANCE METRICS

FY01	SOA	Goal
Hardware Technology		
Nose heaters	5W/cm2	8W/cm2
Pump heaters	40W/cm	60W/cm
Tether	0.9cm DIA	0.3cm DIA
Tether Deploy	spool	spoolless
Electronics Package	7000cm3	3500cm3
High voltage	120VDC	400VDC
Icy Sample	clear	mixed
Instrument package	0	4
Performance Technology		
Temperature	-25C	-70C
Thermal Efficiency	75%	85%
Descent Performance	0.4m/hr	1.2m/hr
Ice/sediment mobility	10micron; 5%	750micron; 10%
Sensor control	open loop	closed loop
FY02	**SOA**	**Goal**
Hardware Technology		
bio-signature instrument	0	1
acoustic driver package	4000 cm3	1000 cm3
Performance Technology		
steering	verticle	5 deg off axis
obsticle avoidance	none	10 meters
Descent depth	5m	300m

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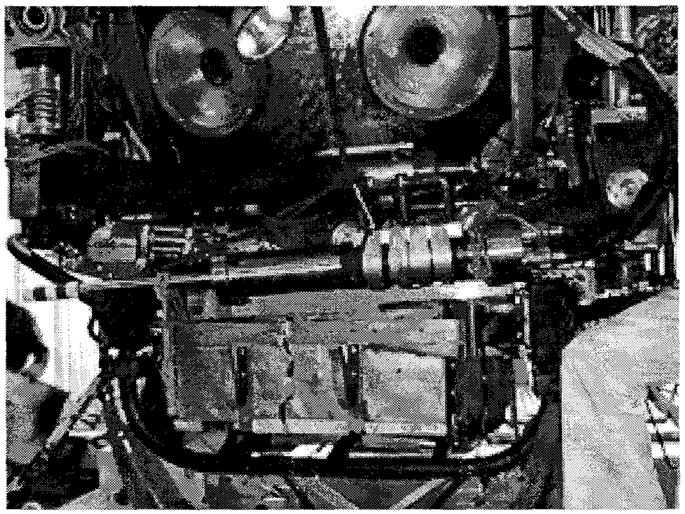
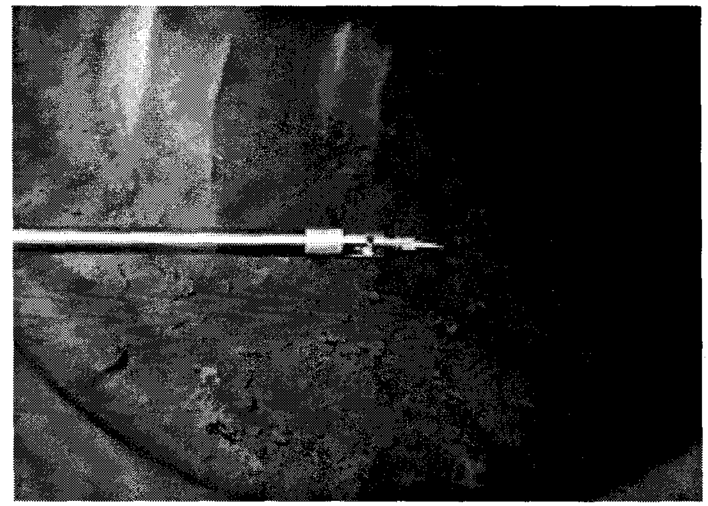
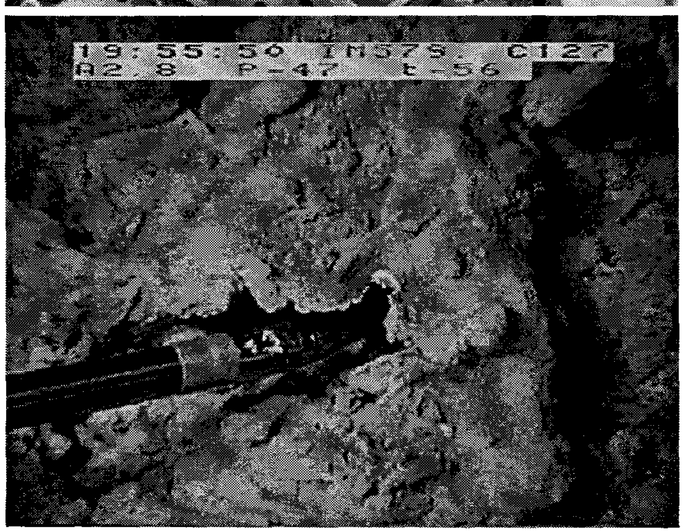
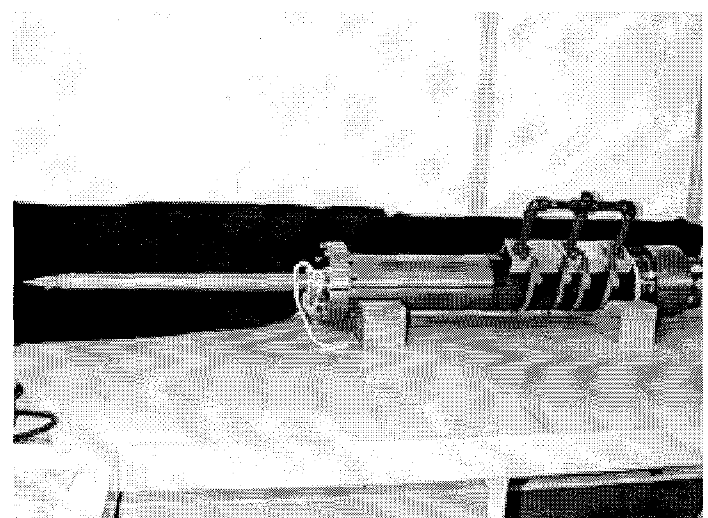
HIGH PRESSURE INSTRUMENTATION: Hydrothermal Vent (Deep Water) Probe









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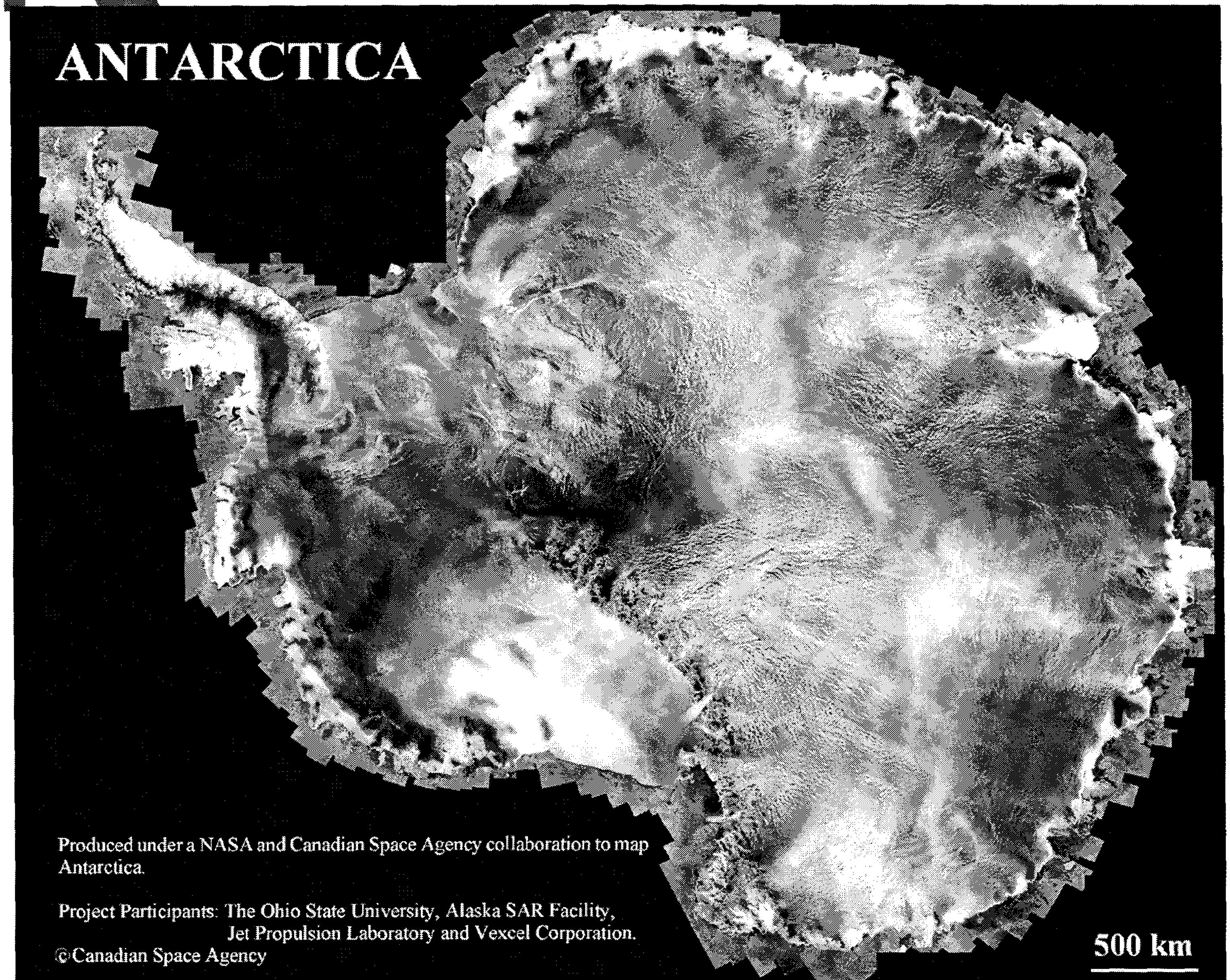

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Antarctic Borehole Photography

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Antarctic Borehole Photography

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Polar Traverse Rover: Earth, Mars, Europa

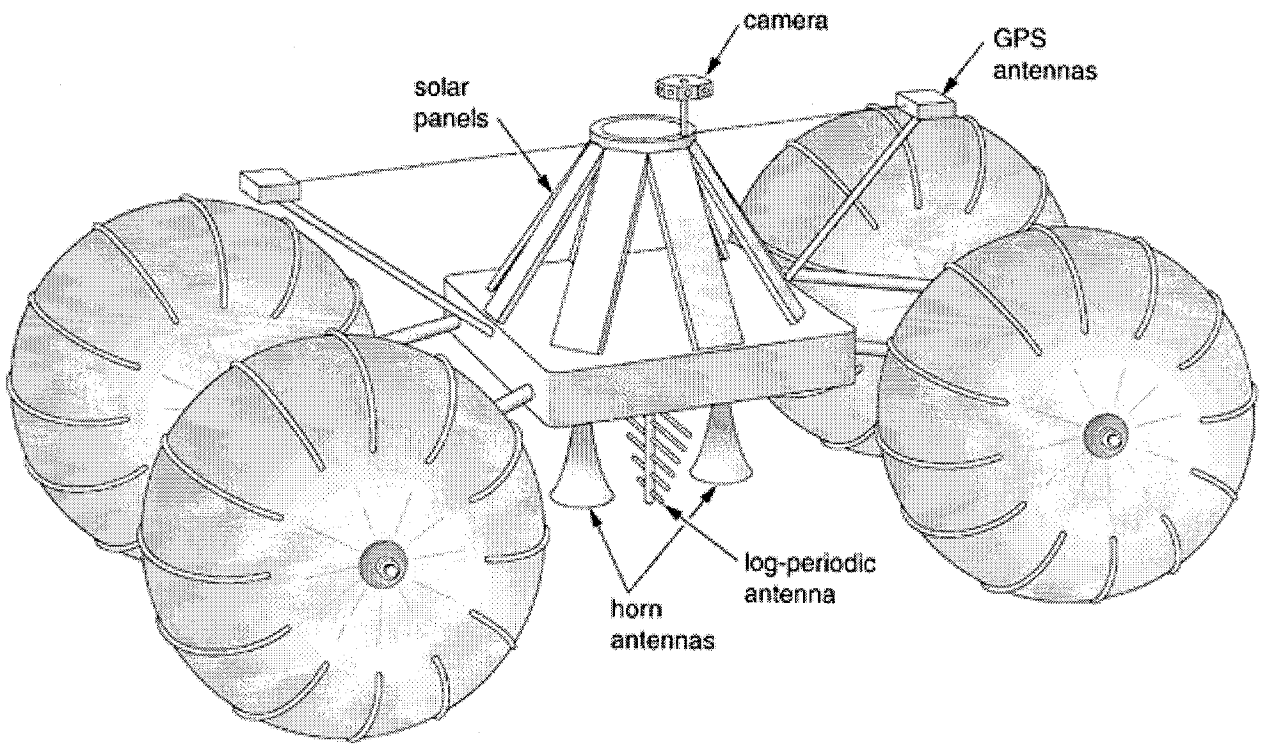

Figure 2. Schematic Diagram of Long-Range Rover.
To accomplish steering, each wheel is independently driven by motors that are not shown. Tire tread details are under study for traction on slopes and to hold against wind. The key electronic and software subsystems are derived directly from rover systems that have flown, such as Sojourner, or will fly in the next 5 years. Solar panel elements may be replaced by cylindrical array of somehwat smaller panels; cost, mass and windage are the issues.

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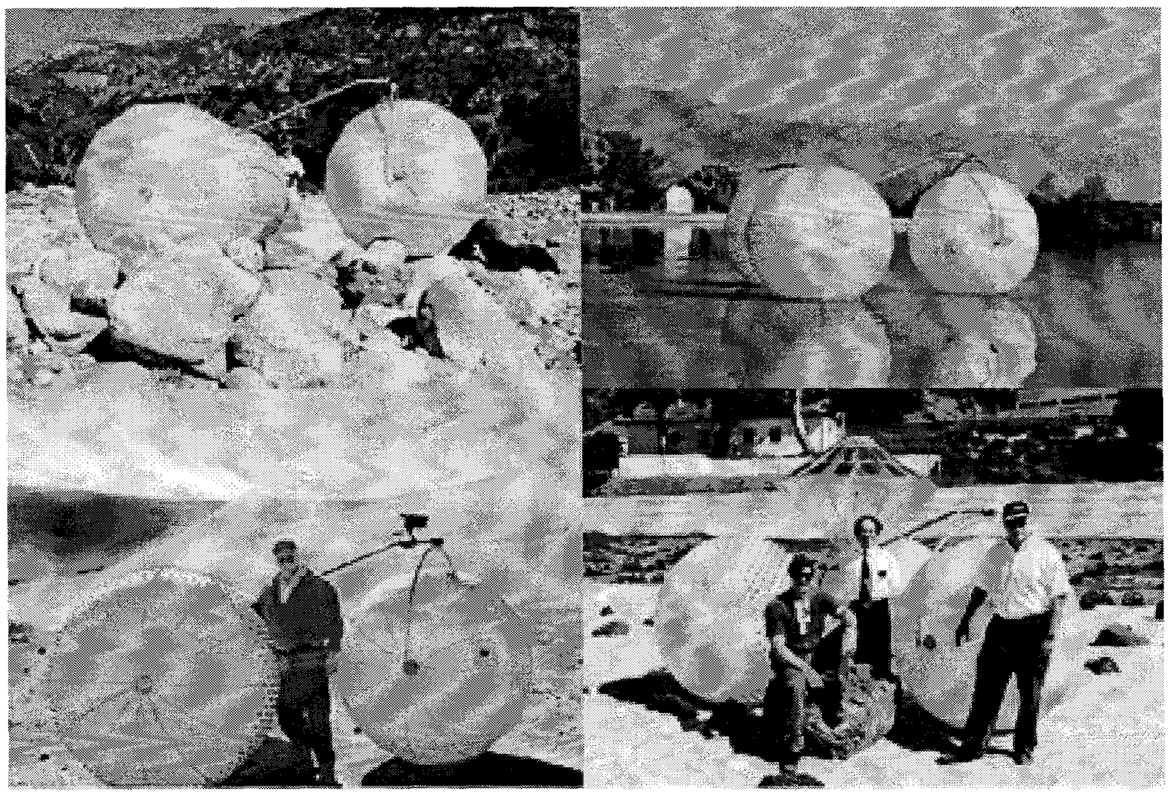
Figure 1 Inflatable Rover Engineering Model
Rover wheels are 1.5 m diameter. The proposed vehicle would probably have smaller wheels for stability in winds. JPL staff shown for scale; all scenes are in California where the trafficability of the rover was examined.



THE INFLATABLE ROVER DRIVES ON ALL TERRAINS

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In Summary: Ice In-Situ Exploration Technology: Complex Task But Moving Forward

- New Data on Earth and Planetary Ice Calls For Deep Subsurface In-Situ Exploration
- First Results of Ice Borehole Probe From Antarctica Illustrate Utility of In-Situ Methods
- **Recalling Scientific In-Situ Sample Acquisition Strategy--**
  Where on planet/Where at site/What sample/What in sample?
- **We Are Making Initial Headway:**
  Sounding Radar Regional Documentation
  Access to the Deep Subsurface
  Micro-Instrumentation for In-Situ Science
- We Have Found It Necessary to Involve Many Funding Sources
  - Nothing New In That